

LTE Exposure assessment and Extrapolation

Wout Joseph^{1*}, Leen Verloock¹, Francis Goeminne¹, Günter Vermeeren¹, and Luc Martens¹

¹Department of Information Technology, Ghent university/IBBT, G. Crommenlaan 8 box 201, B-9050 Ghent, Belgium

*Corresponding author e-mail: wout.joseph@intec.ugent.be

INTRODUCTION

There is a need for the assessment of human exposure to electromagnetic radiation from emerging mobile network technologies. Long Term Evolution (LTE) is a new mobile network technology marketed as the fourth generation (4G) of radio technologies [1]. The world's first publicly available LTE-service was started in 2009. In several countries, network operators are planning rollouts.

In this study, we provide a range of experimentally determined typical radio frequency (RF) exposure values in an urban environment and compare the LTE contribution with other sources. Moreover we determine the worst-case LTE values from instantaneous LTE exposure by an extrapolation method. In this way, LTE exposure is assessed for the maximal emission level when the base station is operating at full capacity. The method is validated for various traffic loads and output powers.

MATERIALS AND METHODS

The measurements were executed in February 2011 at 40 locations in the urban environment of Reading (UK), where a trial LTE network, consisting of 7 LTE base stations (BS) operating in an single frequency network (SFN) at 2.680 GHz with a channel bandwidth of 20 MHz is operational. The measurement locations, outdoor and indoor, are randomly selected across Reading in order to compare base station exposure of various sources (Figure 1). We characterize in-situ exposure of the different RF sources in the frequency range between 80 MHz and 3 GHz at different locations (denoted as short-term or spot measurements).

The measurement setup for the short-term measurements consisted of tri-axial Rohde and Schwarz TS-EMF Isotropic Antennas (dynamic range of 1 mV/m – 100 V/m for a frequency range of 80 MHz – 3 GHz) in combination with a spectrum analyzer (SA) (frequency range of 9 kHz – 6 GHz) (type FSL6, Rohde and Schwarz). “LTE analyzer measurements” are executed to develop an extrapolation method for LTE to determine the worst-case exposure from instantaneously measured exposure values. This setup consisted of an LTE analyzer and Romes software (type R&S TSMW, Rohde and Schwarz, sensitivity: -123 dBm) together with the measurement probes of above. This analyzer is used to scan the different present cell IDs and the corresponding power of the reference signal (P_{RS}).

To estimate the worst-case value or the maximal exposure level (E_{max}) of the LTE signal at each measurement location, equation (1) is proposed:

$$E_{max} = \sqrt{n_{RS}} \cdot E_{RS} \quad (V/m) \quad (1)$$

With E_{RS} the electric field value of the reference signal RS and n_{RS} the ratio of the maximum total output power at the base station to the power of the reference signal RS at the base station. n_{RS} is provided by the network operator or can be calculated theoretically. One has thus only to measure E_{RS} with the LTE analyzer and using (1), E_{max} can be calculated. A

similar method to obtain E_{max} can be proposed using the secondary synchronization signal (S-SYNC) and an extra scaling factor of 17.9 dB. Both methods give similar results with deviations less than 0.5 dB due to environmental differences. A 20 MHz bandwidth is used in the LTE test network in Reading and a power ratio (n_{RS}) of 30.79 dB has been provided by the trial operator.

RESULTS

Figure 1 shows a map of Reading, UK, with the locations of the LTE base stations, the measurement locations and the total measured field values. The red markers indicate the locations of the LTE base stations. All measured electric-field values in Reading satisfy the ICNIRP guidelines [1]. The maximal total value E_{tot} equals 4.5 V/m (52.9 mW/m²) (location 3 in Figure 1). This value is mainly due to the GSM signals (2.8 V/m for GSM900 and 3.1 V/m for GSM1800). Total exposure varies between 0.09 V/m and 4.5 V/m. The total values are in general dominated by the FM signal (55% of the locations). Exposure levels for LTE of 0.2 V/m on average and maximally 0.5 V/m are measured. Contributions of LTE to the exposure are limited to 0.4% on average.

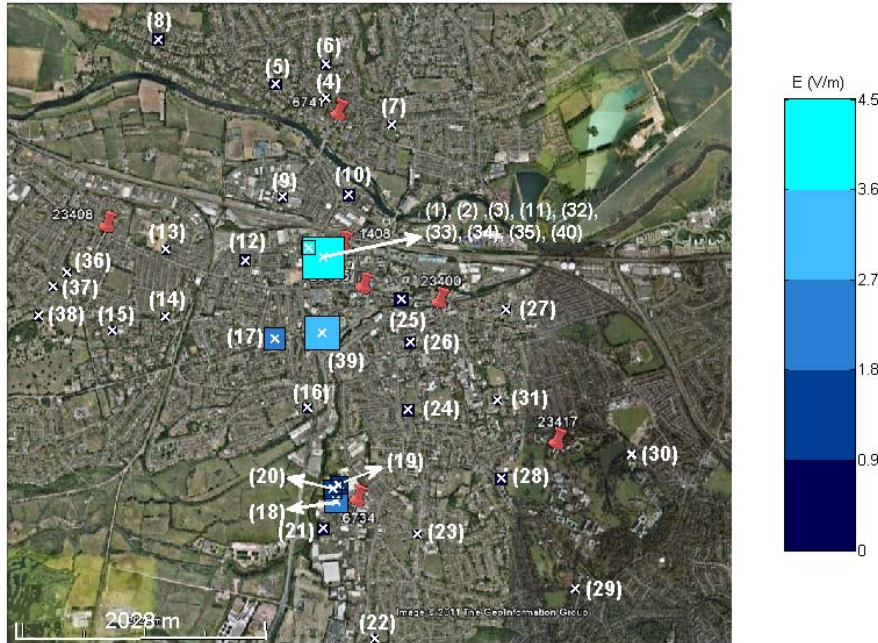


Figure 1: Total electric-field strength (E (V/m)) at the measurement locations on a map of Reading (the dimensions of the squares give an indication of the size of the measured electric-field strength, “x” = measurement locations, red markers refer to the LTE base stations).

The influence of the traffic load and output power of the base station on in-situ RS and S-SYNC signals are lower than 1 dB for all power and traffic load settings, showing that these signals can be used for the extrapolation method.

Table 1 summarizes the extrapolated electric-field values (E_{max} in V/m and dBμV/m) of the LTE signal for all locations. Also the resulting maximal power density S_{max} and EQ (exposure quotient in % i.e., $100 \cdot (S_{max})/L_S$, L_S = ICNIRP reference level for power density) are listed. Highest electric fields are obtained at outdoor locations in line of sight (LOS) with LTE base stations. The maximal value is measured in LOS and in the direction of the main lobe of an LTE base station and equals 1.9 V/m (3.2% of ICNIRP) or a power density of

9.9 mW/m² (0.1% of ICNIRP). On average, the extrapolated electric-field value equals 0.15 V/m and the power density 0.06 mW/m².

TABLE 1: *Extrapolation of measured values for the LTE signal at 40 locations in Reading.*

LTE extrapolated values E_{\max}				
	E_{\max} (dB μ V/m)	E_{\max} (V/m)	S_{\max} (mW/m ²)	EQ (%)
variation	53.5-125.7	0.001-1.9	$5.9 \cdot 10^{-7}$ -9.9	0.00-0.11
average	103.72	0.15	0.06	$6.3 \cdot 10^{-4}$

CONCLUSIONS

In-situ (LTE) exposure of the general public in Reading, UK is characterized and an extrapolation method to estimate worst-case LTE exposure is proposed. All electric-field levels satisfy the ICNIRP reference levels. A maximal total electric-field value of 4.5 V/m is obtained. Contributions of LTE to the exposure are limited to 0.4% on average.

An extrapolation method is proposed and validated to assess the worst-case LTE exposure value. The influence of the traffic load and output power of the base station on in-situ RS and S-SYNC signals are lower than 1 dB for all power and traffic load settings. The maximal extrapolated field value for the LTE signal in the trial network equals 1.9 V/m.

ACKNOWLEDGMENTS

W. Joseph is a Post-Doctoral Fellow of the FWO-V (Research Foundation - Flanders). The authors wish to thank the GSMA for the financial support and the cooperation of Vodaphone and Ericsson.

REFERENCES

- [1] 3rd Generation Partnership Project (3GPP). 2011. Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation, release 10, 3GPP TS 36.211 v10.1.0. Sophia-Antipolis Cedex France: 3GPP.
- [2] International Commission on Non-ionizing Radiation Protection, "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up 300 GHz)," Health Physics, Vol. 74, No. 4, pp. 494-522, 1998.